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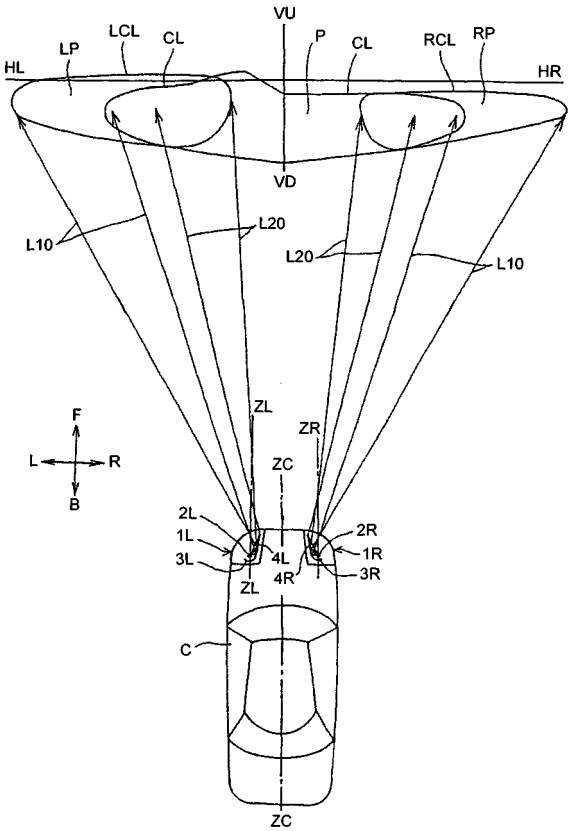
(54) Vehicle headlamp device

(57) A subreflector (4L, 4R) of a vehicle headlamp (1L, 1R) acts as a vertical-wall structure and includes a first sub-reflecting surface (410) that reflects light (L1) from a light source (2L, 2R), and projects a first sub-light-distribution pattern on one side of a main light-distribution pattern (P). The subreflector (4L, 4R) also includes a second sub-reflecting surface (420) that reflects light (L2) from the light source (2L, 2R), and projects a second sub-light-distribution pattern between the main light-distribution pattern (P) and the first sub-light-distribution pattern. One side of the second sub-light-distribution pattern overlaps with the main light-distribution pattern (P), and the other overlaps with the first sub-light-distribution pattern.

FIG.1



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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present document incorporates by reference the entire contents of Japanese priority document, 2005-145286 filed in Japan on May 18, 2005.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention generally relates to a vehicle headlamp device that includes a light source, a main reflector, and a subreflector, and specifically relates to the structure of the subreflector.

2. Description of the Related Art

[0003] A vehicle headlamp device includes a right headlamp and a left headlamp (hereinafter "vehicle headlamps"). Conventional vehicle headlamps including a light source, a main reflector, and a subreflector have been disclosed in, for example, Japanese Patent Application Laid-Open No. 2002-124105. In the conventional vehicle headlamps, when the light source is turned on, light from the light source is reflected off a main reflecting surface and a sub-reflecting surface. The light reflected off the main reflecting surface illuminates the front of the vehicle on which the vehicle headlamps are mounted in a predetermined main light-distribution pattern, e.g., a passing-by light distribution pattern, as indicated by P1 in Fig. 9B. The light reflected off the sub-reflecting surface illuminates the front of the vehicle in a spread sub-light-distribution pattern on the left or right side of the passing-by light distribution pattern as indicated by LP1 or RP1 in Fig. 9B. As shown in Fig. 9B, the conventional vehicle headlamps produce the sub-light-distribution patterns LP1 and RP1 on the left and right sides of the passing-by light distribution pattern P1, respectively, thus improving the visibility of the sides of the vehicle.

[0004] With the conventional vehicle headlamps, however, unlit areas LD and RD (areas encircled by dotted lines in Fig. 9B) are formed between the passing-by light distribution pattern P1 and the sub-light-distribution patterns LP1 and RP1. The unlit areas adversely affect the visibility of the sides of the vehicle.

SUMMARY OF THE INVENTION

[0005] It is an object of the present invention to at least partially solve the problems in the conventional technology.

[0006] According to an aspect of the present invention, a vehicle headlamp device includes a left headlamp configured to be mounted on a left-front side on a vehicle and a right headlamp configured to be mounted on a right-front side on the vehicle. Each of the left headlamp and the right headlamp includes a light source, a main reflector, and a subreflector. The main reflector includes a main reflecting surface that reflects light from the light source, and illuminates the front of the vehicle with the light in a predetermined main light-distribution pattern. The subreflector of the left headlamp is arranged on the right side of the main reflector with respect to a longitudinal axis of the vehicle, and extends forward to form a vertical-wall structure. The subreflector of the right headlamp is arranged on the left side of the main reflector with respect to a longitudinal axis of the vehicle, and extends forward to form a vertical-wall structure. The subreflector includes a first sub-reflecting surface that reflects light from the light source, and illuminates the front of the vehicle with the light in a spread first sub-light-distribution pattern on the left side of the main light-distribution pattern; and a second sub-reflecting surface that reflects light from the light source, and illuminates the front of the vehicle with the light in a spread second sub-light-distribution pattern between the main light-distribution pattern and the first sub-light-distribution pattern, the right side of the second sub-light-distribution pattern overlapping with the main light-distribution pattern and the left overlapping with the first sub-light-distribution pattern. The subreflector includes a first sub-reflecting surface that reflects light from the light source, and illuminates the front of the vehicle with the light in a spread first sub-light-distribution pattern on the right side of the main light-distribution pattern; and a second sub-reflecting surface that reflects light from the light source, and illuminates the front of the vehicle with the light in a spread second sub-light-distribution pattern between the main light-distribution pattern and the first sub-light-distribution pattern, the left side of the second sub-light-distribution pattern overlapping with the main light-distribution pattern and the right overlapping with the first sub-light-distribution pattern.

[0007] The above and other objects, features, advantages and technical and industrial significance of this invention will be better understood by reading the following detailed description of presently preferred embodiments of the invention, when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Fig. 1 is a schematic for explaining light-distribution patterns obtained by a vehicle headlamp device according to a first embodiment of the present invention;

Fig. 2 is a cross-section of a left headlamp shown in Fig. 1;

Fig. 3 is a schematic for explaining the reflection on first and second reflecting surfaces of a subreflector of the left headlamp, and optical paths of lights passing through the opening of a shade;

Fig. 4 is a perspective view of the relevant parts of the left headlamp;
Fig. 5 is another perspective view of the relevant parts of the left headlamp in which part of the shade is cut away;
Fig. 6A is a schematic for explaining an image projected by light that is emitted from a light-emitting unit of a light source and reflected on a segment of the subreflector of the left headlamp;
Fig. 6B is a schematic for explaining an image projected by light reflected on another segment of the subreflector;
Fig. 6C is a schematic for explaining an image projected by light reflected on yet another segment of the subreflector;
Fig. 6D is a schematic for explaining an image projected by light reflected on yet another segment of the subreflector;
Fig. 6E is a schematic for explaining an image projected by light reflected on yet another segment of the subreflector;
Fig. 6F is a schematic for explaining an image projected by light reflected on yet another segment of the subreflector;
Fig. 7A is a schematic for explaining a spread second sub-light-distribution pattern obtained by the second sub-reflecting surface in the left headlamp;
Fig. 7B is a schematic for explaining a spread first sub-light-distribution pattern obtained by the first sub-reflecting surface in the left headlamp;
Fig. 7C is a schematic for explaining a left sub-light-distribution pattern obtained by the subreflector of the left headlamp;
Fig. 7D is a schematic for explaining a passing-by light distribution pattern obtained by a main reflector of the left headlamp;
Fig. 7E is a schematic for explaining the left sub-light-distribution and passing-by light distribution patterns obtained by the subreflector and the main reflector of the left headlamp;
Fig. 8 is a schematic for explaining a light-distribution pattern on a road obtained by the left and right headlamps, represented with isolux-curves;
Fig. 9A is a schematic for explaining light-distribution patterns obtained by the left or right headlamp;
Fig. 9B is a schematic for explaining light-distribution patterns obtained from conventional vehicle headlamps;
Fig. 10 is a schematic for explaining a vehicle headlamp device according to a second embodiment of the present invention; and
Fig. 11 is a schematic for explaining a passing-by light distribution pattern obtained when a movable shade shown in Fig. 10 is in a closed position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] Exemplary embodiments of the present invention are explained below in detail with reference to the accompanying drawings.

[0010] A vehicle headlamp device according to the embodiments includes a left headlamp and right headlamp and produces a combined light-distribution pattern of a passing-by light distribution pattern and spread left and right light-distribution patterns.

[0011] In the drawings, reference character F designates the forward or front side of a motor car (vehicle) C, i.e., the direction in which the motor car C is driven in the front gear; B designates the backside of the motor car C; U designates the upside of the motor car C as viewed forward from the driver side; D designates the downside of the motor car C as viewed forward from the driver side; L designates the left side of the motor car C as viewed forward from the driver side; R designates the right side of the motor car C as viewed forward from the driver side; VU-VD designates a vertical line on a screen; HL-FR designates a horizontal line on the screen; ZL-ZL and ZR-ZR each designate an optical axis; ZC-ZC designates a vehicle axis.

[0012] Referring now to Figs. 1 to 9, a vehicle headlamp device according to a first embodiment is explained. The vehicle headlamp device includes a headlamp 1L mounted on the left-front side of the motor car C (hereinafter, "left headlamp") and a headlamp 1R mounted on the right-front side of the motor car C (hereinafter, "right headlamp").

[0013] The left and right headlamps 1L and 1R are substantially the same but symmetrical in construction (left-right reversed in arrangement), and therefore, one of them, the left headlamp 1L, is described in detail.

[0014] The left headlamp 1L includes, as shown in Figs. 1 and 2, a light source 2L, a fixed main reflector 3L, a fixed subreflector 4L, a fixed shade 6, a lamp housing 50, a lamp lens 51, and an inner panel 53. The right headlamp 1R includes a light source 2R, a fixed main reflector 3R, a fixed subreflector 4R, a fixed shade 6, a lamp housing 50, a lamp lens 51, and an inner panel 53. The lamp housing 50 and the lamp lens 51 define a light chamber 52. In the light chamber 52 are arranged the light source 2L, the main reflector 3L, the subreflector 4L, the fixed shade 6, and the inner panel 53.

[0015] The main reflector 3L is arranged in the lamp housing 50 via an optical-axis adjusting mechanism (not shown) to be capable of adjusting an optical axis in left and right directions about a substantially vertical axis and in up and down directions about a substantially horizontal axis. The front surface of the main reflector 3L provides a main reflecting surface 30. The main reflecting surface 30 reflects light from the light source 2L, and illuminates the front of the motor car C with the light in a predetermined main light-distribution pattern (in this embodiment, a passing-by light distribution pattern P). Near the vertical

axis VU-VD, about which a screen is symmetrical, in the center of the passing-by light distribution pattern P, i.e., the center of the motor car C (vehicle's center), a hot zone (not shown) with high light intensity (brightness, illuminance) is formed. The upper edge of the passing-by light distribution pattern P forms a cut-off line CL. The main reflecting surface 30 of the main reflector 3L is formed by, for example, aluminum evaporation or silver coating, and is a free-form or nonuniform rational B-spline (NURBS).surface.

[0016] As can be seen in Figs. 4 and 5, the main reflecting surface 30 is divided leftward, rightward, upward and downward into a plurality of segments. The optical axis of the main reflecting surface 30 substantially coincides with the optical axis ZL-ZL of the left headlamp 1L. The optical axes ZL-ZL and ZR-ZR of the left and right headlamps 1L and 1R are substantially parallel with a vehicle axis ZC-ZC (i.e., centerline in a longitudinal direction of the motor car C, see Fig. 1). Although Figs. 4 and 5 only show the left headlamp 1L, the main reflecting surface 30 of even the right headlamp 1R is divided into a plurality of segments in the same manner as in the left headlamp 1L. The main reflecting surface 30 and the segments thereof in the right headlamp 1R are substantially symmetrical in arrangement to those in the left headlamp 1L.

[0017] The subreflector 4L of the left headlamp 1L is arranged on the right side R of the main reflector 3L, and extends forward to form a vertical-wall structure. On the other hand, the subreflector 4R of the right headlamp 1R is arranged on the left side L of the main reflector 3R, and extends forward to form a vertical-wall structure.

[0018] The subreflector 4L is formed separately from other members such as the main reflector 3L, the lamp housing 50, the lamp lens 51, and the inner panel 53. The subreflector 4L is fixed to another member (in this embodiment, the main reflector 3L), with a fixing member such as a bracket 54. As shown in Fig. 3, the subreflector 4L includes a platy first portion 41 extending from the front end to an intermediate point and a second portion 42 having a convex shape (in this embodiment, a shape that gets widen toward the end).

[0019] The subreflector 4L is provided with a sub-reflecting surface on the left side, i.e., the side facing the light source 2L. The left sub-reflecting surface reflects light from the light source 2L to illuminate the front of the motor car C with the light in a predetermined left sub-light-distribution pattern LP (in this embodiment, a spread sub-light-distribution pattern LP ranging from the left edge to a little left of the center of the passing-by light distribution pattern P as shown in Fig. 1). Similarly to the subreflector 4L, the subreflector 4R is provided with a sub-reflecting surface on the right side, i.e., the side facing the light source 2L. The right sub-reflecting surface reflects light from the light source 2R to illuminate the front of the motor car C with the light in a predetermined right sub-light-distribution pattern RP (in this embodiment, a spread sub-light-distribution pattern RP ranging from the right edge to a little right of the center of the passing-by light distribution pattern P as shown in Fig. 1). The sub-reflecting surfaces of the subreflectors 4L and 4R are formed by, for example, aluminum evaporation or silver coating, and is a free-form or NURBS surface.

[0020] As can be seen in Figs. 2 and 3, the sub-reflecting surface includes a first sub-reflecting surface 410 and a second sub-reflecting surface 420. The first sub-reflecting surface 410 reflects light L1 from the light source 2L to illuminate the front of the motor car C with the light L1 in a spread first sub-light-distribution pattern LP10 (see Fig. 7B) on the left side of the passing-by light distribution pattern P. The second sub-reflecting surface 420 reflects light L2 from the light source 2L to illuminate the front of the motor car C with the light L2 in a spread second sub-light-distribution pattern LP20 (see Fig. 7A). The second sub-light-distribution pattern LP20 is formed between the passing-by light distribution pattern P and the first sub-light-distribution pattern LP10, with one side overlapping with the passing-by light distribution pattern P and the other overlapping with the first sub-light-distribution pattern LP10. The first sub-reflecting surface 410 is formed on the first portion 41 of the subreflector 4L, while the second sub-reflecting surface 420 is formed on the second portion 42 of the subreflector 4L.

[0021] Referring to Figs. 4 and 5, the sub-reflecting surface consists of the front and back parts, i.e., the first and second sub-reflecting surfaces 410 and 420. The first and second sub-reflecting surfaces 410 and 420 are each divided in vertical direction into three segments. Thus, the sub-reflecting surface includes six segments (blocks) 411, 412, 413, 421, 422, and 423. Although Figs. 4 and 5 only show the left headlamp 1L, even the sub-reflecting surface of the right headlamp 1R is divided into the first and second sub-reflecting surfaces 410 and 420 including six segments 411 to 413 and 421 to 423 in the same manner as in the left headlamp 1L. The first and second sub-reflecting surfaces 410 and 420, and the six segments 411 to 413 and 421 to 423 in the right headlamp 1R are substantially symmetrical in arrangement to those in the left headlamp 1L.

[0022] The upper edge of the left sub-light-distribution pattern LP forms a cut-off line LCL. On the other hand, the upper edge of the right sub-light-distribution pattern RP forms a cut-off line RCL. The cut-off line LCL of the left sub-light-distribution pattern LP emitted from the left headlamp 1L on the road-shoulder side is located upper than the cut-off line RCL of the right sub-light-distribution pattern RP emitted from the right headlamp 1R.

[0023] While boundaries between the first and second sub-reflecting surfaces 410 and 420 and the six segments 411 to 413 and 421 to 423 are shown in Figs. 4 and 5, such boundaries in fact may be invisible when these segments are formed in one sequence. Besides, the number of segments is cited here is merely exemplary, in other words, there can be more or less the number of segments mentioned here. For a more com-

plete description of the NURBS surface, reference may be had to "Mathematical Elements for Computer Graphics" by David F. Rogers, J. Alan Adams, which is incorporated herein by reference.

[0024] Examples of the light source 2L include, but not limited to, high-pressure metal-vapor discharge lamps such as metal halide lamps and discharge lamps such as high intensity discharge (HID) lamps. As shown in Fig. 5, the light source or discharge lamp 2L includes an arc tube 200 as a light-emitting unit, an outer tube 201 that is a tubular bulb and covers the arc tube 200, and a cap 202 that supports the base ends of the arc tube 200 and the outer tube 201. The arc tube 200 is filled with a noble gas, quicksilver, metal iodide, and the like. In the arc tube 200, an electrode on the side of the cap 202 is arranged opposite to an electrode on the side of a lead connected via a ceramic pipe to the end of the outer tube 201 with a little space between them. When a voltage is applied to the electrodes, an arc discharge occurs in the arc tube 200 whereby the arc tube 200 emits light. As in the left headlamp 1L, a discharge lamp is used as the light source 2R in the headlamp 1R.

[0025] The light source axis (bulb axis) Z-Z connects the opposed electrodes together. On the outer tube 201 are formed two light-blocking stripes (black stripes), which is not shown in the drawings, in the direction of the light source axis Z-Z. The light-blocking stripes form the cut-off lines CL, LCL and RCL at the upper edges of the passing-by light distribution pattern P, the left sub-light-distribution pattern LP and the right sub-light-distribution pattern RP. By rotating the light sources (discharge lamps) 2L and 2R a predetermined degree around their respective light source axes Z-Z, a passing-by light distribution pattern can be obtained for driving on the right side.

[0026] The light source 2L is detachably mounted to the main reflector 3L via the cap 202 and a socket (not shown). The light source 2L is arranged so that the longitudinal axis of the arc tube 200 is on the optical axis of the main reflecting surface 30, and also the center of the arc tube 200 is on the optical axis ZL-ZL of the left headlamp 1L. That is, the light sources 2L is laid out in the optical-axis direction. The longitudinal axis of the arc tube 200 substantially coincides with the light source axis Z-Z. In addition, the optical axis ZL-ZL of the left headlamp 1L and the optical axis ZR-ZR of the right headlamp 1R are substantially parallel to the vehicle axis ZC-ZC. Thus, the light source axis Z-Z is substantially parallel to the vehicle axis ZC-ZC.

[0027] The inner panel 53 is fixed to the lamp housing 50. The inner panel 53 prevents the structure behind the main reflector 3L and the subreflector 4L from being exposed through the space between the lamp housing 50 and the main reflector 3L as well as the space between the lamp housing 50 and the subreflector 4L when viewed from the lamp-lens 51 side to improve the appearance.

[0028] The fixed shade 6 is placed between the light source 2L and the subreflector 4L. The fixed shade 6 is fixed to the lamp housing 50 or the main reflector 3L. The fixed shade 6 has an opening 60. The opening 60 allows only desired light, the light L1 or L2 from the light source 2L, to be incident on the first sub-reflecting surface 410 or the second sub-reflecting surface 420. Thereby, the opening 60 provides the first sub-light-distribution pattern LP10 or the second sub-light-distribution pattern LP20. Besides, the fixed shade 6, except the opening 60, shields light penetration so that light from the light source 2L is not incident on an undesired part.

[0029] The operation of the left headlamp 1L is explained below. When the arc tube 200 of the light source 2L is lighted, light from the arc tube 200 reflects off the main reflecting surface 30 of the main reflector 3L. The reflected light illuminates the front of the motor car C in the passing-by light distribution pattern P as a predetermined main light-distribution pattern as shown in Fig. 1. A hot zone is formed in the center of the passing-by light distribution pattern P. The upper edge of the passing-by light distribution pattern P forms the cut-off line CL.

[0030] The lights L1 and L2 from the arc tube 200 pass through the opening 60 of the fixed shade 6, and reflect off the segments 411 to 413 in the first sub-reflecting surface 410 and the segments 421 to 423 in the second sub-reflecting surface 420 of the subreflector 4L. Lights L10 and L20 reflected off the segments 411 to 413 and 421 to 423 illuminate the front of the motor car C in the predetermined spread sub-light-distribution pattern LP as shown in Fig. 1. The sub-light-distribution pattern LP ranges from the left edge to a little left of the center of the passing-by light distribution pattern P. On the other hand, the sub-light-distribution pattern RP ranges from the right edge to a little right of the center of the passing-by light distribution pattern P. The upper edges of the sub-light-distribution patterns LP and RP form the cut-off lines LCL and RCL, respectively. The cut-off line LCL of the sub-light-distribution pattern LP emitted from the left headlamp 1L on the road-shoulder side is located upper than the cut-off line RCL of the sub-light-distribution pattern RP emitted from the right headlamp 1R.

[0031] If part of the light L1 that has passed through the opening 60 is incident on the top segment 411 of the first sub-reflecting surface 410 in the left headlamp 1L, the light reflection forms a pattern of a projection image as shown Fig. 6D. If part of the light L1 is incident on the middle segment 412 of the first sub-reflecting surface 410, the light reflection forms a pattern of a projection image as shown Fig. 6E. Additionally, if part of the light L1 is incident on the bottom segment 413 of the first sub-reflecting surface 410, the light reflection forms a pattern of a projection image as shown Fig. 6F. A combination of the projection-image patterns of Figs. 6D, 6E and 6F forms the first sub-light-distribution pattern LP10 shown in Fig. 7B. In other words, the light L1 that has passed through the opening 60 reflects off the three segments 411 to 413 of the first sub-reflecting surface 410. The reflected light L10 illuminates the front of the motor car C in the spread first sub-light-distribution pattern LP10

on the left side of the passing-by light distribution pattern P.

[0032] If part of the light L2 that has passed through the opening 60 is incident on the top segment 421 of the second sub-reflecting surface 420 in the left headlamp 1L, the light reflection forms a pattern of a projection image as shown Fig. 6A. If part of the light L2 is incident on the middle segment 422 of the second sub-reflecting surface 420, the light reflection forms a pattern of a projection image as shown Fig. 6B. Additionally, if part of the light L2 is incident on the bottom segment 423 of the second sub-reflecting surface 420, the light reflection forms a pattern of a projection image as shown Fig. 6C. A combination of the projection-image patterns of Figs. 6A, 6B and 6C forms the second sub-light-distribution pattern LP20 shown in Fig. 7A. In other words, the light L2 that has passed through the opening 60 reflects off the three segments 421 to 423 of the second sub-reflecting surface 420. The reflected light L20 illuminates the front of the motor car C in the spread second sub-light-distribution pattern LP20. The second sub-light-distribution pattern LP20 is formed between the passing-by light distribution pattern P and the first sub-light-distribution pattern LP10, with one side overlapping with the passing-by light distribution pattern P and the other overlapping with the first sub-light-distribution pattern.

[0033] A combination of the first sub-light-distribution pattern LP10 and the second sub-light-distribution pattern LP20 forms the left sub-light-distribution pattern LP shown in Fig. 7C. Further, a combination of the left sub-light-distribution pattern LP and the passing-by light distribution pattern P shown in Fig. 7D forms a wide light-distribution pattern WP shown in Fig. 7E on the left side. As with the left headlamp 1L, the right headlamp 1R produces a wide light-distribution pattern (not shown) on the right side. As a result, as shown in Fig. 1, the left and right headlamps 1L and 1R produce the passing-by light distribution pattern P as well as the left and right sub-light-distribution patterns LP and RP on the left and right sides of the passing-by light distribution pattern P. Incidentally, the shape of the left and right sub-light-distribution patterns LP and RP can be changed by adjusting the shape of the opening 60.

[0034] Fig. 8 is a schematic for explaining a light-distribution pattern on a road represented with isolux-curves. A combination of the passing-by light distribution pattern P, the left sub-light-distribution pattern LP and the right sub-light-distribution pattern RP form the light-distribution pattern as shown in Fig. 8. As shown in Fig. 9A, in the light-distribution pattern of Fig. 8, the left side of the passing-by light distribution pattern P in large part (checkered part in Fig. 9A) overlaps with the right side of the left sub-light-distribution pattern LP. Similarly, the right side of the passing-by light distribution pattern P in large part (checkered part in Fig. 9A) overlaps with the left side of the right sub-light-distribution pattern RP.

[0035] As described above, according to the first embodiment of the present invention, the vehicle headlamp device (left and right headlamps 1L and 1R) produces the spread first sub-light-distribution patterns on the left and right sides of the passing-by light distribution pattern P through the first sub-reflecting surface 410 (segments 411 to 413). In addition, the vehicle headlamp device produces the spread second sub-light-distribution patterns through the second sub-reflecting surface 420 (segments 421 to 423). The second sub-light-distribution pattern is formed between the passing-by light distribution pattern P and the first sub-light-distribution pattern, with one side overlapping with the passing-by light distribution pattern P and the other overlapping with the first sub-light-distribution pattern. That is, the vehicle headlamp device can illuminate areas on the left and right sides of the passing-by light distribution pattern P with the spread first sub-light-distribution patterns. The vehicle headlamp device can also illuminate areas between the passing-by light distribution pattern P and the respective first sub-light-distribution patterns with the spread second sub-light-distribution patterns. As indicated by the checkered part in Fig. 9A, the left side of the passing-by light distribution pattern P in large part overlaps with the right side of the left sub-light-distribution pattern LP, while the right side of the passing-by light distribution pattern P in large part overlaps with the left side of the right sub-light-distribution pattern RP. Thereby, the vehicle headlamp device can prevent unlit areas between the passing-by light distribution pattern P and the sub-light-distribution patterns LP and RP. Consequently, the vehicle headlamp device reliably improves the visibility of the sides of a vehicle, thus contributing to traffic safety.

[0036] In the vehicle headlamp device, the subreflectors 4L and 4R have a vertical-wall structure, and are formed separately from other members such as the main reflectors 3L and 3R, the lamp housing 50, the lamp lens 51, and the inner panel 53. Therefore, the subreflectors 4L and 4R as well as the other members have a simple structure, and can be formed by simple metal molding. As a result, manufacturing costs can be reduced. Additionally, because the subreflectors 4L and 4R is formed separately from other members, it is possible to precisely form the platy first portion 41 extending from the front end to an intermediate point of each of the subreflectors 4L and 4R, and the second portion 42 having a convex shape in the back part thereof. Moreover, the first sub-reflecting surface 410 and the second sub-reflecting surface 420 can be formed with high accuracy on the first portion 41 and the second portion 42, respectively. Accordingly, the first sub-light-distribution pattern and the second sub-light-distribution pattern can be controlled precisely with high accuracy. In particular, because of the construction of the subreflectors 4L and 4R, it is possible to prevent distortion of the second sub-reflecting surface 420 due to the surface sink of the second portion 42. Thus, the second sub-light-distribution pattern can be controlled precisely with high accuracy.

[0037] Further, the first sub-reflecting surface 410 is provided on the platy first portion 41 extending from the

front end to an intermediate point of the subreflector (4L, 4R). With the first sub-reflecting surface 410, the first sub-light-distribution patterns can be formed easily and reliably on the left and right sides of the passing-by light distribution pattern P. On the other hand, the second sub-reflecting surface 420 is provided on the second portion 42 having a convex shape in the back part of the subreflector (4L, 4R). With the second sub-reflecting surface 420, the second sub-light-distribution patterns can be formed easily and reliably between the passing-by light distribution pattern P and the respective first sub-light-distribution patterns. Besides, the light sources 2L and 2R are laid out in the optical-axis direction. That is, in the light sources 2L and 2R, the longitudinal axis of the arc tube 200 coincides with the optical axis (ZL-ZL, ZR-ZR) of the headlamp (1L, 1R). Consequently, the second sub-reflecting surface 420 is closer to the light source (2L, 2R) compared to the first sub-reflecting surface 410. As a result, the illuminance or brightness of the second sub-light-distribution pattern formed by the second sub-reflecting surface 420 is higher than the first sub-light-distribution pattern formed by the first sub-reflecting surface 410. Thus, from the passing-by light distribution pattern P through the second sub-light-distribution pattern to the first sub-light-distribution pattern, the illuminance or brightness gradually decreases, which is suitable for the light distribution patterns of vehicle headlamps.

[0038] Still further, the fixed shade 6 is placed between the light source (2L, 2R) and the subreflector (4L, 4R). The opening 60 of the fixed shade 6 reliably causes the lights L1 and L2 from the light source (2L, 2R) to be incident on the first sub-reflecting surface 410 and the second sub-reflecting surface 420, respectively. The fixed shade 6, except the opening 60, shields light penetration so that light (i.e., direct light or light distribution of which is uncontrollable) from the light source (2L, 2R) is not incident on parts other than the first and second sub-reflecting surfaces 410 and 420. With the fixed shade 6, the first sub-light-distribution pattern and the second sub-light-distribution pattern can be appropriately controlled. Additionally, the shape of the first and second sub-light-distribution patterns can be changed by adjusting the shape of the opening 60, which facilitates light-distribution design.

[0039] Furthermore, as shown in Fig. 1, the cut-off line LCL of the left sub-light-distribution pattern LP on the left side of the passing-by light distribution pattern P, i.e., on the road-shoulder side, is located a little upper than the cut-off line RCL of the right sub-light-distribution pattern RP. Accordingly, a pedestrian is clearly visible and recognizable. On the other hand, the cut-off line RCL of the right sub-light-distribution pattern RP on the right side of the passing-by light distribution pattern P, i.e., on the oncoming-lane side (right side), is located a little upper than the cut-off line LCL of the left sub-light-distribution pattern LP. Consequently, it is possible to prevent glare to oncoming drivers. Namely, the vehicle headlamp device can produce a desirable passing-by light distribution pattern, thus contributing to traffic safety.

[0040] Referring next to Figs. 10 and 11, a vehicle headlamp device according to a second embodiment is explained. Like reference characters are utilized in designating corresponding portions. The vehicle headlamp device of the second embodiment is in many respects basically similar to that of the first embodiment except for the presence of a movable shade 61. The movable shade 61 is arranged so that the opening 60 of the fixed shade 6 can be opened and closed. The movable shade 61 makes opening and closing movements by an actuator (not shown) such as a solenoid, a motor and a cylinder. The actuator is connected to a controlling unit (not shown). To the controlling unit are connected a vehicle-running-state sensor (not shown) including a steering-angle sensor and a vehicle-speed sensor.

[0041] While the motor car C is driving normally, the vehicle-running-state sensor detects the normal running state of the motor car C, and outputs a detection signal to the controlling unit. Having determined that the motor car C is driving normally based on the detection signal, the controlling unit outputs a close signal to the actuator. According to the close signal, the actuator moves the movable shade 61 in the open position (position indicated by a two-dot chain line in Fig. 10) to close the opening 60 with the movable shade 61. The movable shade 61 in the closed position shields the lights L1 and L2 from each of the light sources 2L and 2R that have passed through the opening 60 as shown in Fig. 10. Consequently, as shown in Fig. 11, the left and right sub-light-distribution patterns LP and RP are not formed, and only the passing-by light distribution pattern P is formed. Thereby, it is possible to prevent discomfort glare (e.g. glare caused by light from the first and second sub-reflecting surfaces 410 and 420, which is reflected off a guide rail, etc.) from being produced, and contribute to traffic safety.

[0042] On the other hand, while the motor car C is cornering, the vehicle-running-state sensor detects the cornering state of the motor car C, and outputs a detection signal to the controlling unit. Having determined that the motor car C is cornering based on the detection signal, the controlling unit outputs an open signal to the actuator. According to the open signal, the actuator moves the movable shade 61 in the closed position (position indicated by a solid line in Fig. 10) to open the opening 60. The lights L1 and L2 from each of the light sources 2L and 2R that have shielded by the movable shade 61 pass through the opening 60 as shown in Fig. 10. Consequently, as shown in Fig. 1, the left and right sub-light-distribution patterns LP and RP are formed on the left and right sides of the passing-by light distribution pattern P. Thereby, it is possible to improve visibility in the direction the motor car C is turning, and contribute to traffic safety.

[0043] In the first and second embodiments, a discharge lamp, such as a D2R or D4R bulb, with two light-blocking stripes (black stripes) is used as the light source (2L, 2R). Examples of the light source include, but not limited to, a discharge lamp other than a D2R or D4R

bulb, a halogen bulb and an incandescent bulb.

[0044] While the first and second embodiments describe vehicle headlamps that create a passing-by light distribution pattern P, such vehicle headlamps are intending to include any headlamps that produce other types of light-distribution patterns. Examples of light-distribution patterns include, but not limited to, a driving-light distribution pattern and a light-distribution pattern for freeway driving. In addition, the present invention can be applied to fog lamps that provide a foglight distribution pattern. In such headlamps and fog lamps, the sub-reflecting surfaces produce left and right sub-light-distribution patterns suitable for each of them.

[0045] The above discussion pertains principally to the case of left-hand traffic. In the case of right-hand traffic, the vehicle headlamp device provides left-right reversed light-distribution patterns (main light-distribution pattern and sub-light-distribution patterns).

[0046] Incidentally, the longitudinal direction of a light-emitting portion coincides with that of the arc tube 200, in which an arc is generated. When a halogen bulb, an incandescent bulb etc. is used as the light source, the longitudinal direction of a light-emitting portion coincides with that of the filament of the halogen bulb or the incandescent bulb.

[0047] In the first and second embodiments, the subreflector (4L, 4R) is formed separately from other members. However, the subreflector can be formed integral with another member, e.g., the main reflector.

[0048] Although the invention has been described with respect to a specific embodiment for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching herein set forth.

Claims

1. A vehicle headlamp device that comprises a left headlamp (1L) configured to be mounted on a left-front side on a vehicle (C) and a right headlamp (1R) configured to be mounted on a right-front side on the vehicle (C), each of the left headlamp (1L) and the right headlamp (1R) includes a light source (2L, 2R), a main reflector (3L, 3R), and a subreflector (4L, 4R), wherein

the main reflector (3L, 3R) includes a main reflecting surface (30) that reflects light from the light source (2L, 2R), and illuminates the front of the vehicle (C) with the light in a predetermined main light-distribution pattern (P),

the subreflector (4L) of the left headlamp (1L) is arranged on the right side of the main reflector (3L) with respect to a longitudinal axis of the vehicle (C), and extends forward to form a vertical-wall structure, the subreflector (4R) of the right headlamp (1R) is arranged on the left side of the main reflector (3R) with respect to a longitudinal axis of the vehicle (C), and extends forward to form a vertical-wall structure, the subreflector (4L) includes

a first sub-reflecting surface (410) that reflects light (L1) from the light source (2L), and illuminates the front of the vehicle (C) with the light (L1) in a spread first sub-light-distribution pattern on the left side of the main light-distribution pattern (P); and

a second sub-reflecting surface (420) that reflects light (L2) from the light source (2L), and illuminates the front of the vehicle (C) with the light (L2) in a spread second sub-light-distribution pattern between the main light-distribution pattern (P) and the first sub-light-distribution pattern, the right side of the second sub-light-distribution pattern overlapping with the main light-distribution pattern (P) and the left overlapping with the first sub-light-distribution pattern, and

the subreflector (4R) includes

a first sub-reflecting surface (410) that reflects light (L1) from the light source (2R), and illuminates the front of the vehicle (C) with the light (L1) in a spread first sub-light-distribution pattern on the right side of the main light-distribution pattern (P); and

a second sub-reflecting surface (420) that reflects light (L2) from the light source (2R), and illuminates the front of the vehicle (C) with the light (L2) in a spread second sub-light-distribution pattern between the main light-distribution pattern (P) and the first sub-light-distribution pattern, the left side of the second sub-light-distribution pattern overlapping with the main light-distribution pattern (P) and the right overlapping with the first sub-light-distribution pattern.

2. The vehicle headlamp device according to claim 1, wherein the subreflector (4L, 4R) is formed separately from other members (3L, 3R, 50, 51, 53), and is fixed to any one of the other members (3L, 3R, 50, 51, 53) with a fixing member (54).

3. The vehicle headlamp device according to claim 1 or 2, wherein the subreflector (4L, 4R) includes a platy first portion (41) having the first sub-reflecting surface (410), and a convex second portion (42) having the second sub-reflecting surface (420).

4. The vehicle headlamp device according to any one of claims 1 to 3, wherein the first portion (41) extends from the front end to an intermediate point of the subreflector (4L, 4R), and

the second portion (42) is located in the back part of

the subreflector (4L, 4R)

5. The vehicle headlamp device according to any one of claims 1 to 4, wherein
the light source (2L, 2R) is oriented in an optical-axis direction.

6. The vehicle headlamp device according to any one of claims 1 to 5, further comprising a shade (6), wherein
the shade (6) is arranged between the light source (2L, 2R) and the subreflector (4L, 4R), and
the shade (6) has an opening (60) that allows the light (L1, L2) from the light source (2L, 2R) to be incident on the first sub-reflecting surface (410) and the second sub-reflecting surface (420) to form the first sub-light-distribution pattern and the second sub-light-distribution pattern.

7. The vehicle headlamp device according to claim 6, further comprising a movable shade (61) that opens and closes the opening (60).

FIG.1

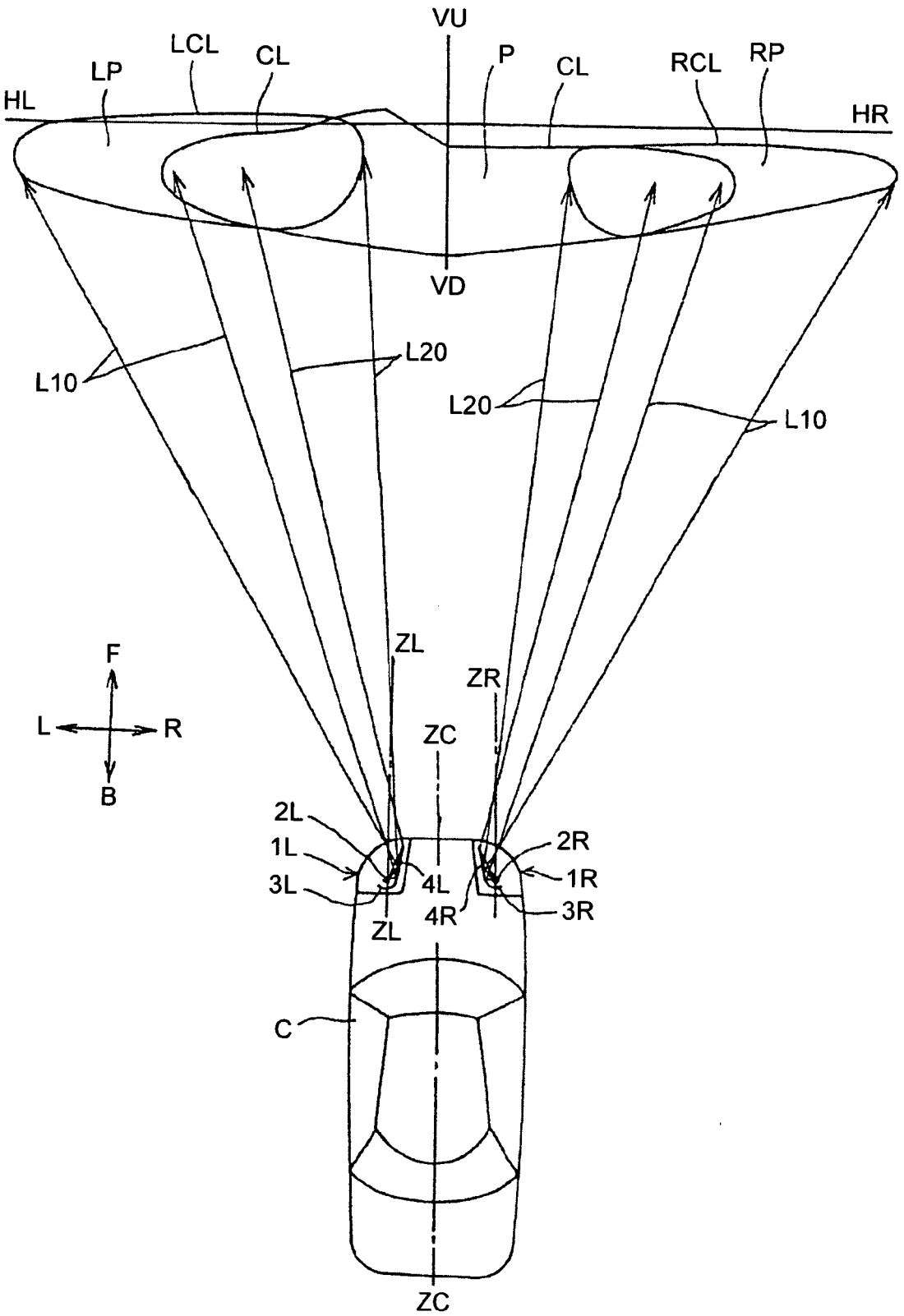

VU
LCL
CL
P
CL
RCL
RP
LP
HL
HR
VD
L10
L20
L20
L10
F
L
R
B
ZL
ZR
ZC
2L
1L
3L
4L
4R
2R
1R
3R
ZL
C
ZC

FIG.2

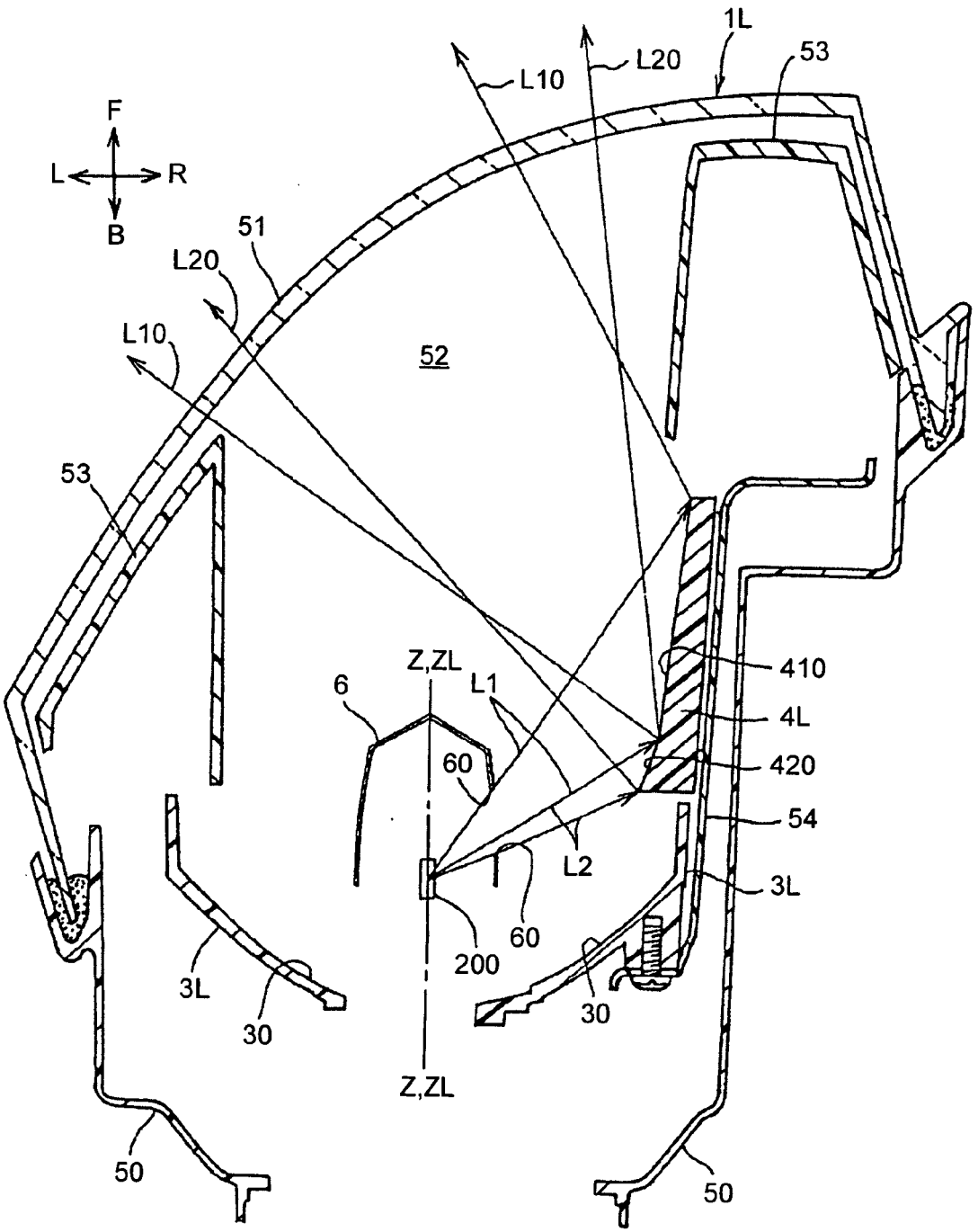

F
L
R
B
1L
L10
L20
53
51
L20
L10
52
53
Z,ZL
6
L1
60
410
4L
420
54
L2
3L
60
200
3L
30
30
Z,ZL
50
50

FIG.3

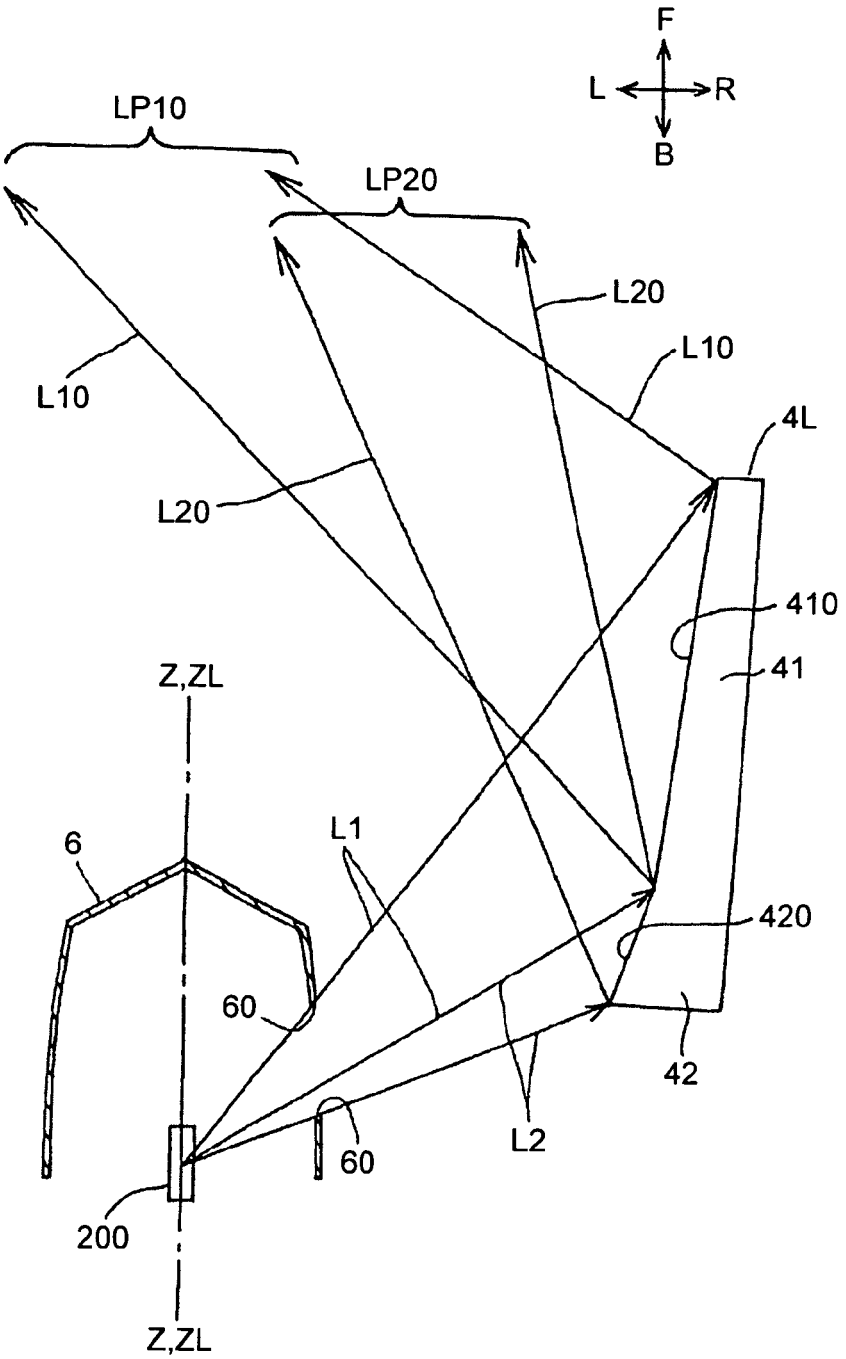

F
L
R
B
LP10
LP20
L20
L10
L10
4L
L20
410
41
Z,ZL
6
L1
420
60
42
60
L2
200
Z,ZL

FIG.4

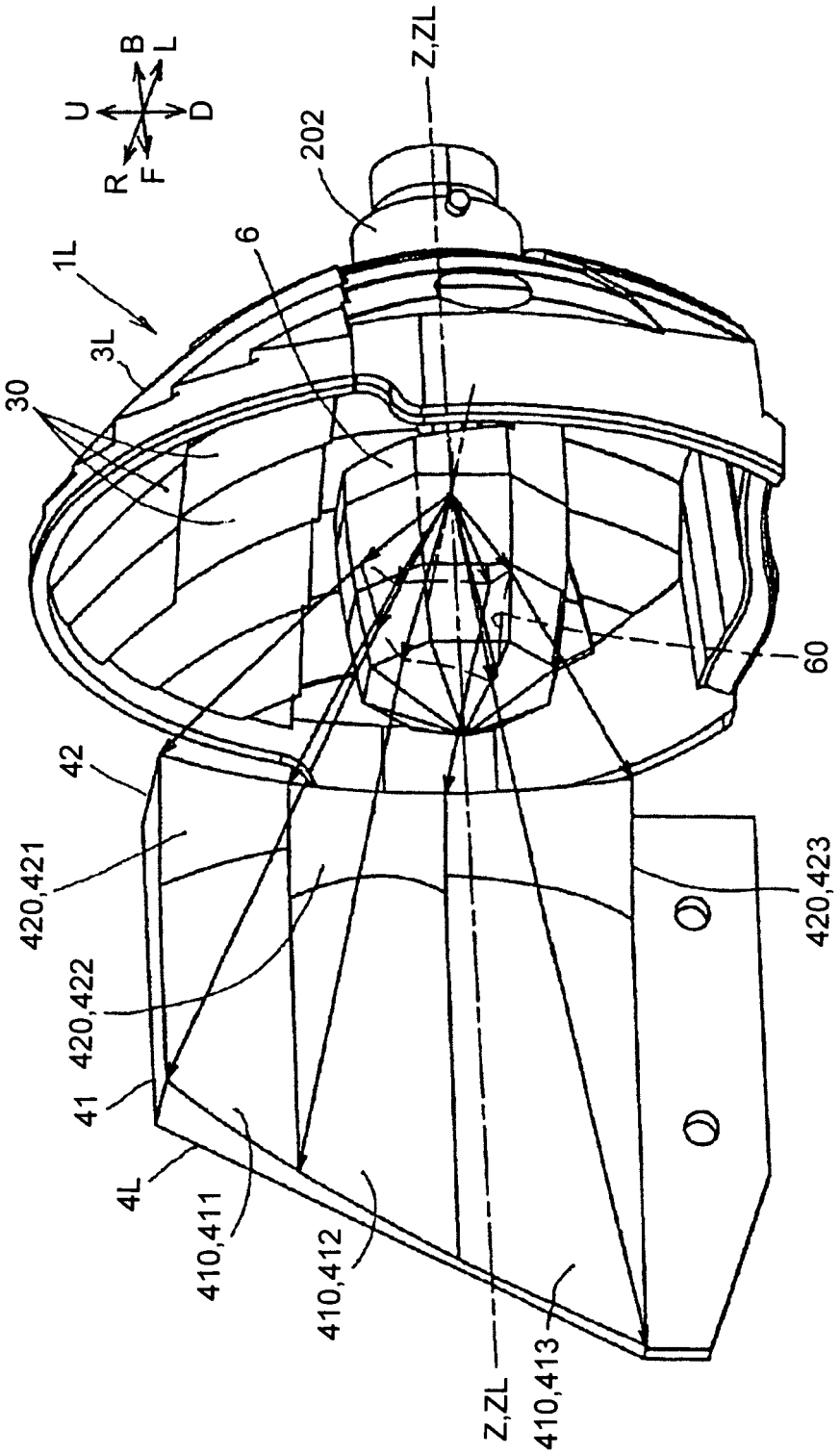

U
D
B
L
R
F
Z,ZL
202
6
1L
3L
30
60
42
420,421
420,422
41
4L
410,411
410,412
420,423
Z,ZL
410,413

FIG.5

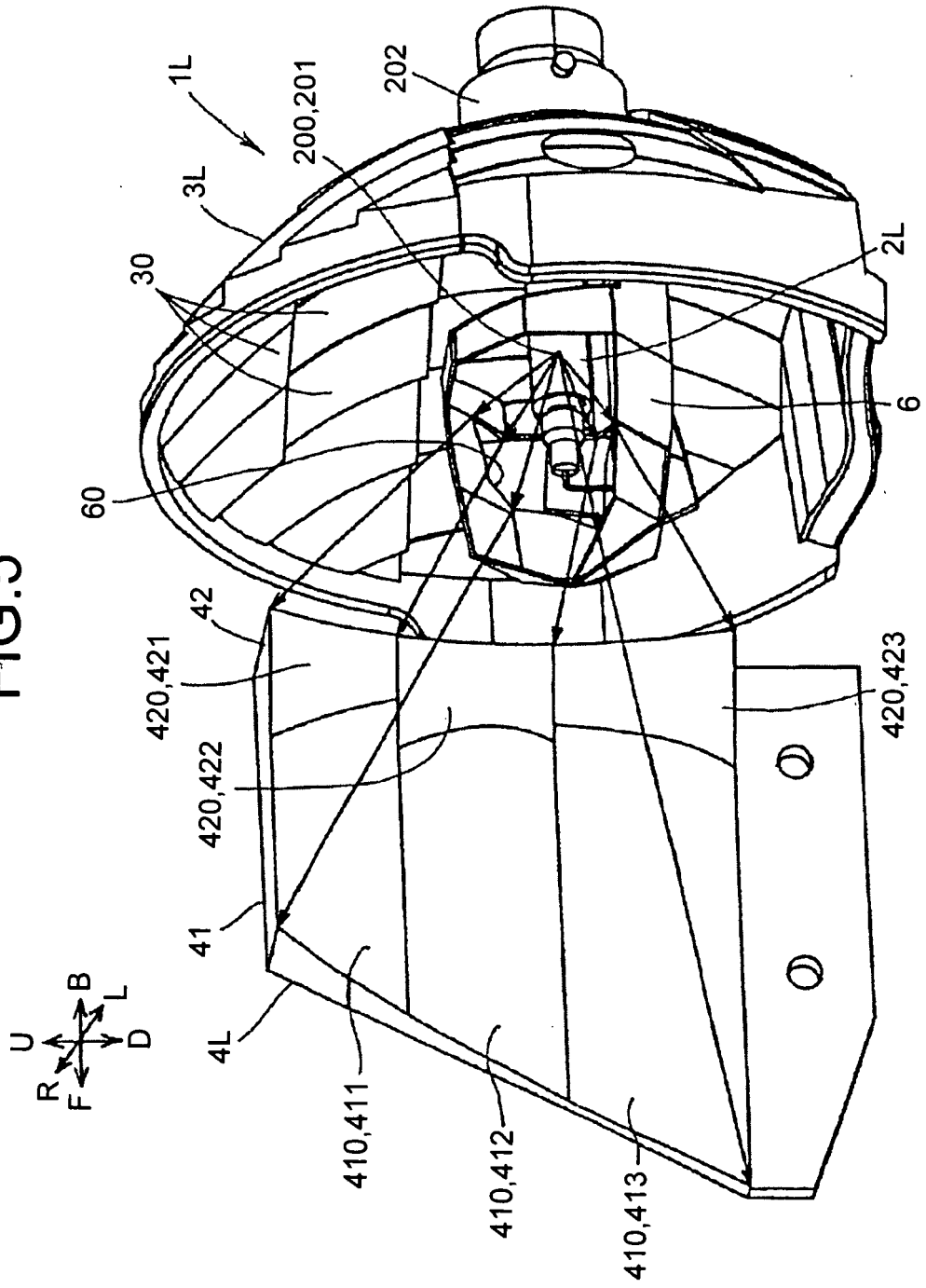

1L
200,201
202
3L
30
2L
6
60
42
420,421
420,423
420,422
41
4L
410,411
410,412
410,413
U
D
B
L
R
F

FIG.6A

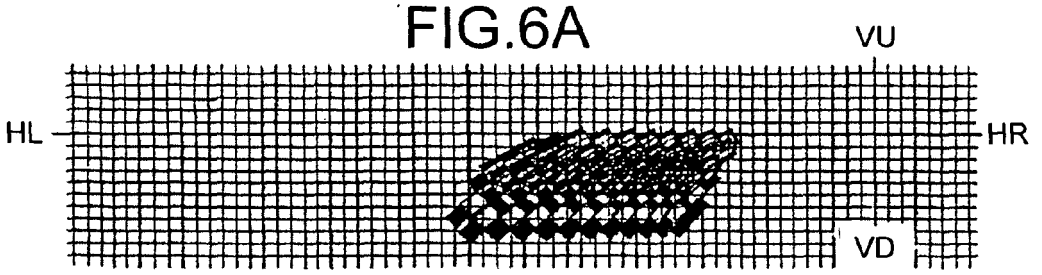


FIG.6B

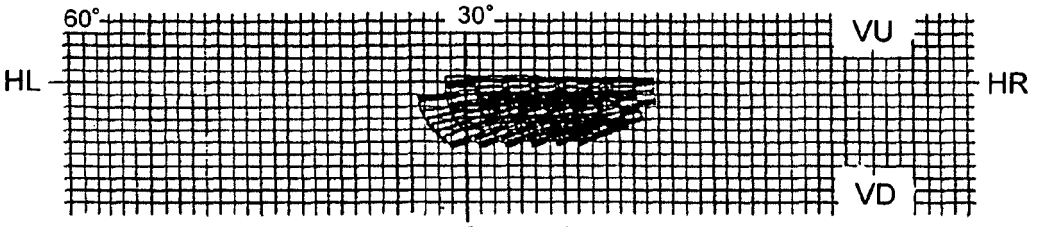


FIG.6C

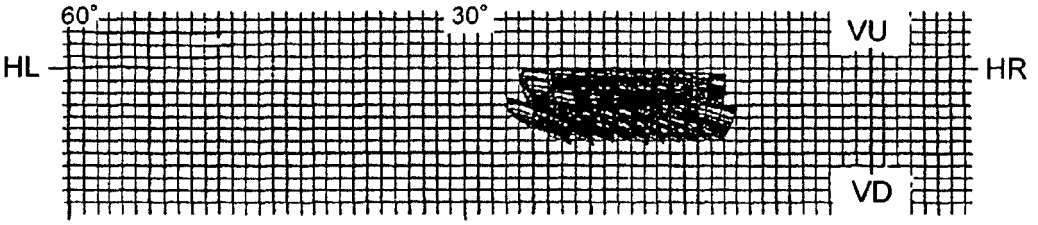


FIG.6D

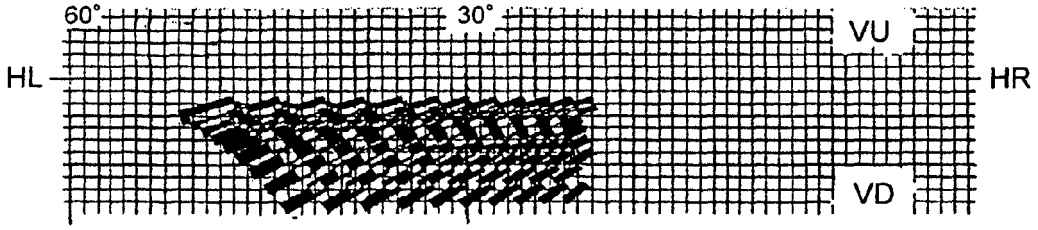


FIG.6E

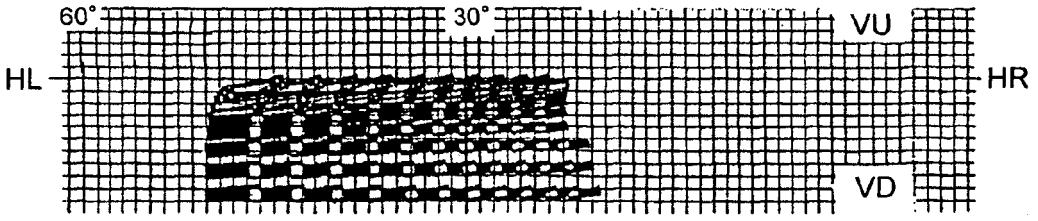


FIG.6F

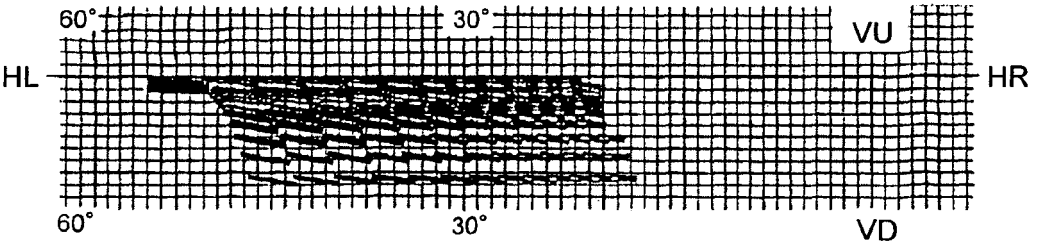


FIG.7A

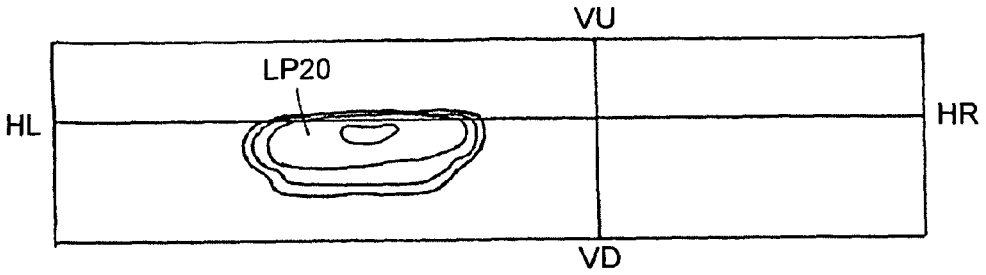


FIG.7B

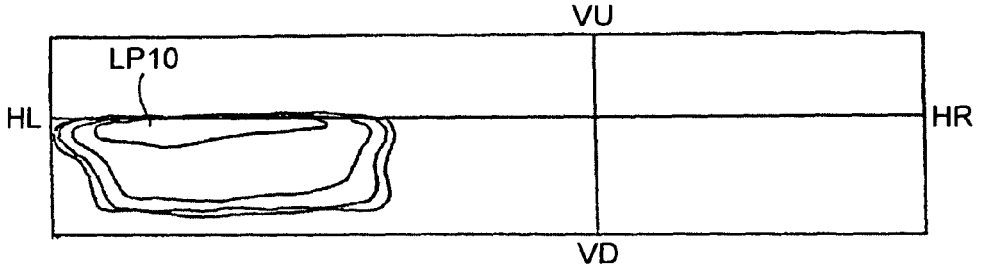


FIG.7C

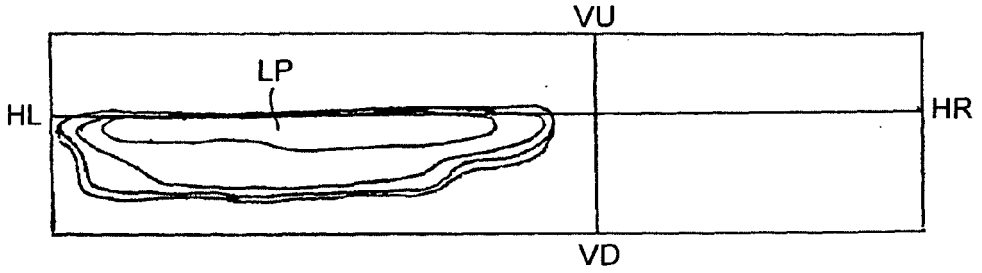


FIG.7D

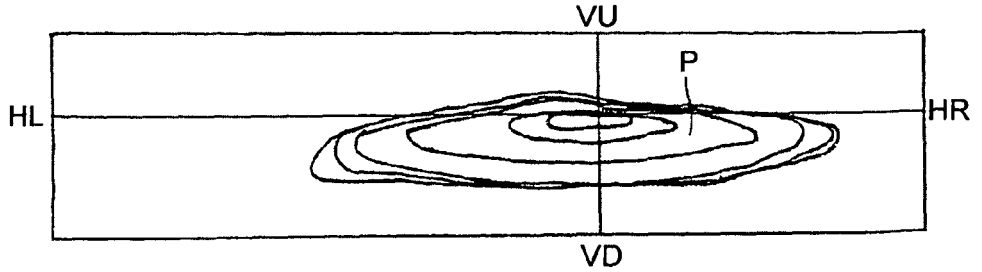


FIG.7E

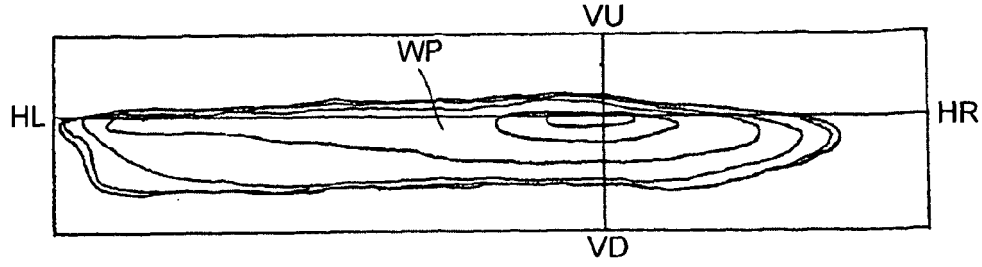


FIG.8

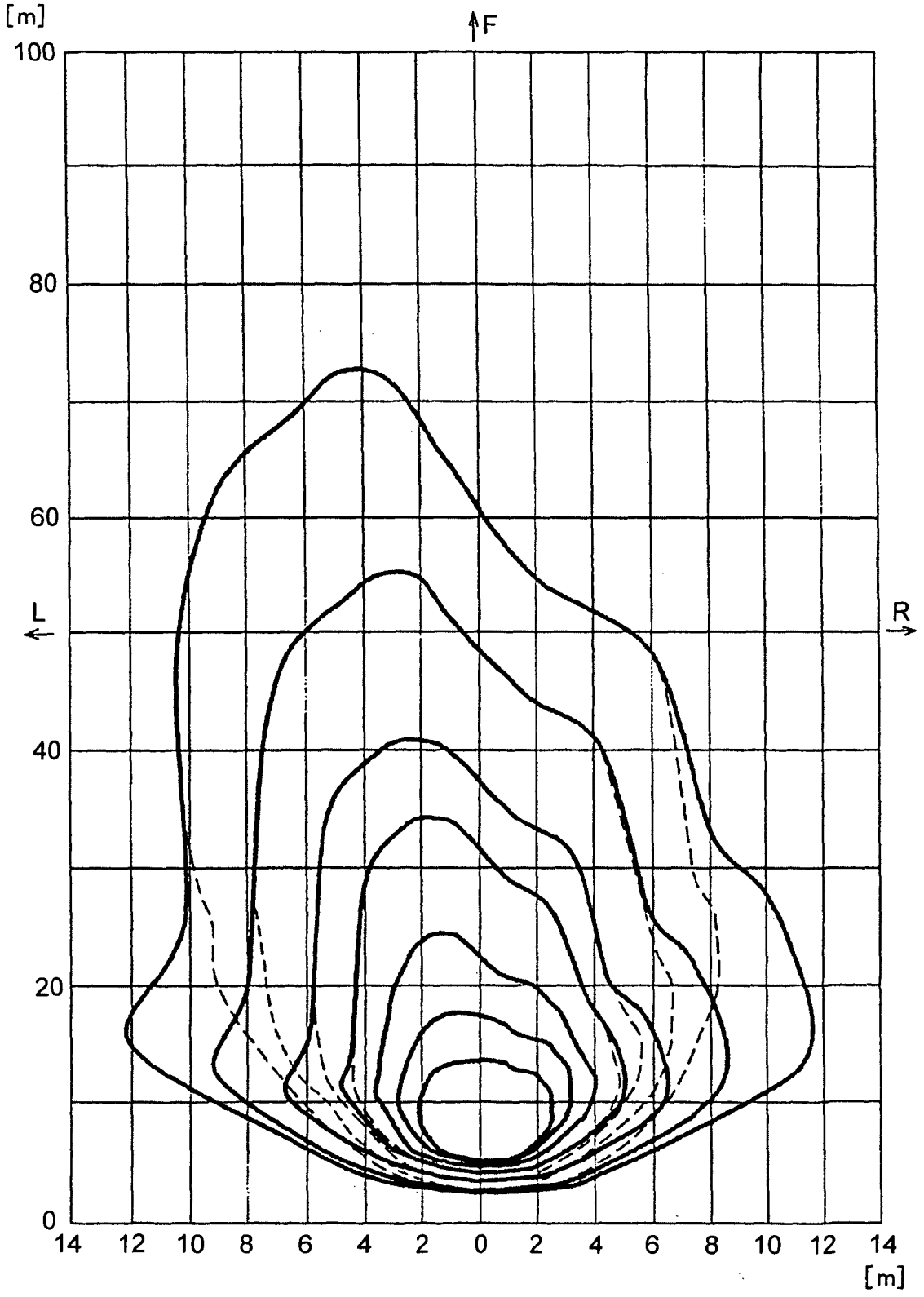


FIG.9A

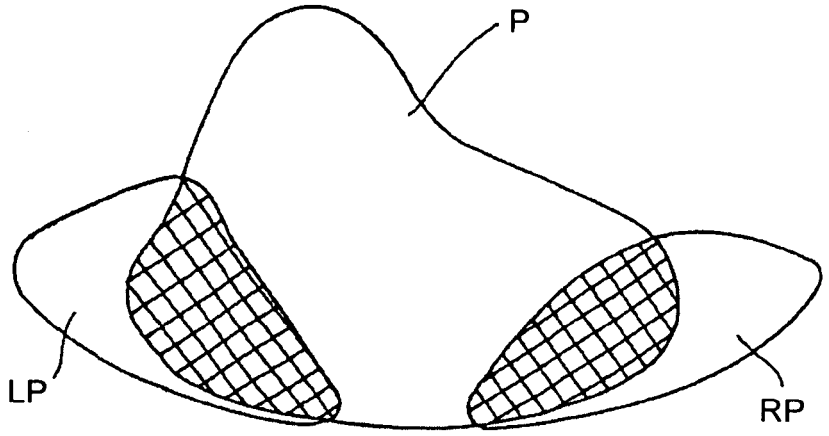


FIG.9B

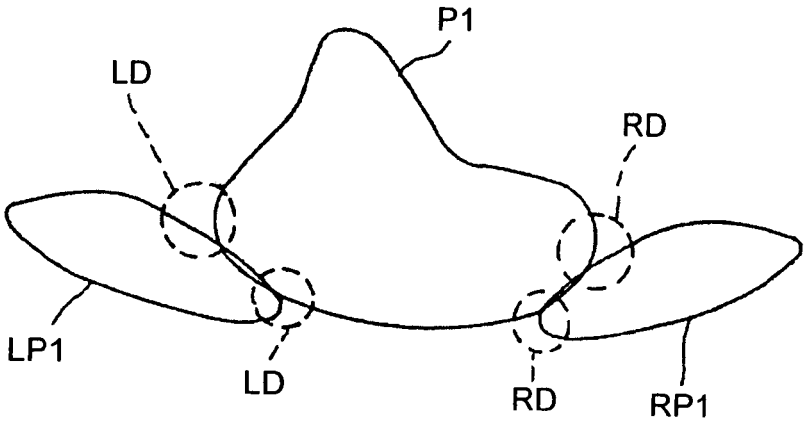


FIG.10

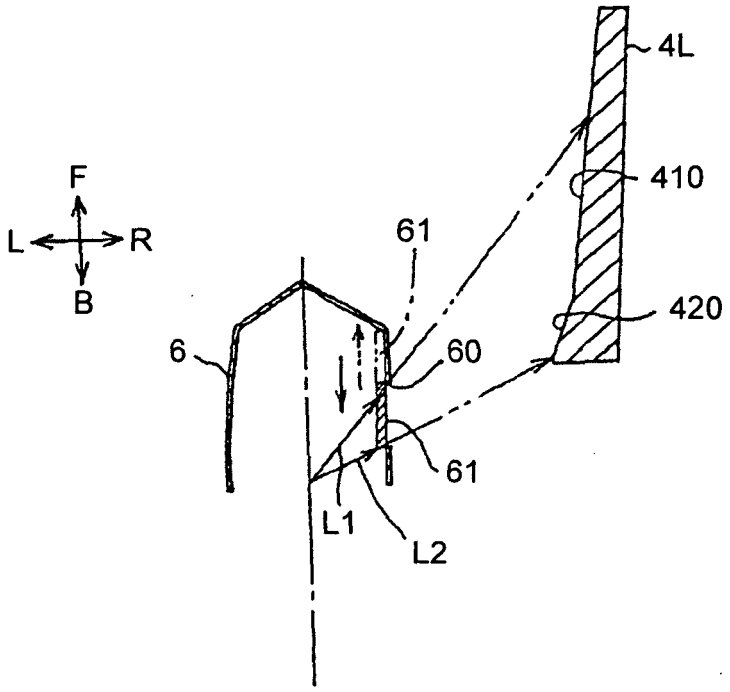
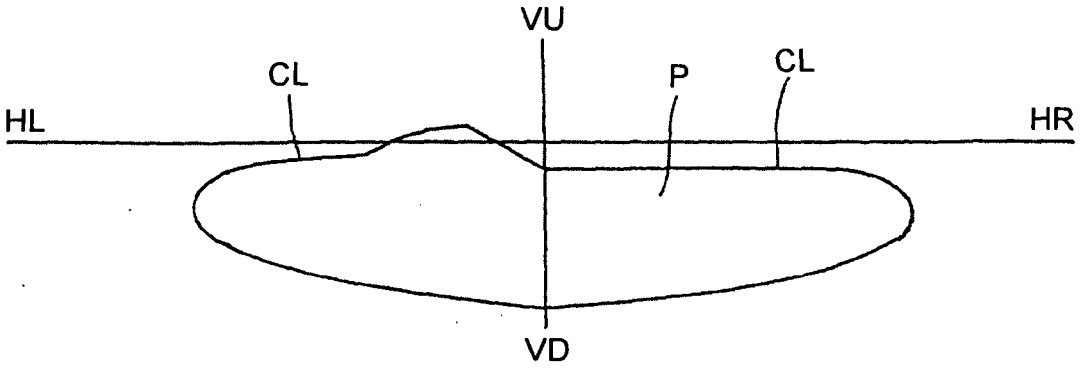


FIG.11



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005145286 A **[0001]**
- JP 2002124105 A **[0003]**